be updated by the addition and/or subtraction of images from the template. A template update process may be performed by processor **104** to add and/or subtract template images from the template space. For example, the template space may be updated with additional images to adapt to changes in the authorized user's appearance and/or changes in hardware performance over time. Images may be subtracted from the template space to compensate for the addition of images when the template space for storing template images is full.

[0034] In some embodiments, camera module **102** captures multiple pairs of images for a facial recognition session. Each pair may include an image captured using a two-dimensional capture mode (e.g., a flood IR image) and an image captured using a three-dimensional capture mode (e.g., a depth map image). In certain embodiments, ISP **110** and/or SEP **112** process the flood IR images and depth map images independently of each other before a final authentication decision is made for the user. For example, ISP **110** may process the images independently to determine characteristics of each image separately. SEP **112** may then compare the separate image characteristics with stored template images for each type of image to generate an authentication score (e.g., a matching score or other ranking of matching between the user in the captured image and in the stored template images) for each separate image. The authentication scores for the separate images (e.g., the flood IR and depth map images) may be combined to make a decision on the identity of the user and, if authenticated, allow the user to use device **100** (e.g., unlock the device).

[0035] In some embodiments, ISP **110** and/or SEP **112** combine the images in each pair to provide a composite image that is used for facial recognition. In some embodiments, ISP **110** processes the composite image to determine characteristics of the image, which SEP **112** may compare with the stored template images to make a decision on the identity of the user and, if authenticated, allow the user to use device **100**.

[0036] In some embodiments, the combination of flood IR image data and depth map image data may allow for SEP **112** to compare faces in a three-dimensional space. In some embodiments, camera module **102** communicates image data to SEP **112** via a secure channel. The secure channel may be, for example, either a dedicated path for communicating data (i.e., a path shared by only the intended participants) or a dedicated path for communicating encrypted data using cryptographic keys known only to the intended participants. In some embodiments, camera module **102** and/or ISP **110** may perform various processing operations on image data before supplying the image data to SEP **112** in order to facilitate the comparison performed by the SEP.

[0037] In certain embodiments, processor **104** operates one or more machine learning models. Machine learning models may be operated using any combination of hardware and/or software (e.g., program instructions) located in processor **104** and/or on device **100**. In some embodiments, one or more neural network modules **114** are used to operate the machine learning models on device **100**. Neural network modules **114** may be located in ISP **110** and/or SEP **112**.

[0038] Neural network module **114** may include any combination of hardware and/or software (e.g., program instructions) located in processor **104** and/or on device **100**. In some embodiments, neural network module **114** is a multi-scale neural network or another neural network where the scale of kernels used in the network can vary. In some embodiments, neural network module **114** is a recurrent neural network (RNN) such as, but not limited to, a gated recurrent unit (GRU) recurrent neural network or a long short-term memory (LSTM) recurrent neural network.

[0039] Neural network module **114** may include neural network circuitry installed or configured with operating parameters that have been learned by the neural network module or a similar neural network module (e.g., a neural network module operating on a different processor or device). For example, a neural network module may be trained using training images (e.g., reference images) and/or other training data to generate operating parameters for the neural network circuitry. The operating parameters generated from the training may then be provided to neural network module **114** installed on device **100**. Providing the operating parameters generated from training to neural network module **114** on device **100** allows the neural network module to operate using training information programmed into the neural network module (e.g., the training-generated operating parameters may be used by the neural network module to operate on and assess images captured by the device).

[0040] FIG. **4** depicts a flowchart for an embodiment of occlusion detection process **200**. In certain embodiments, process **200** is implemented using neural network module **114** (another network module and/or another machine learning model) associated with ISP **110**. Process **200** may begin with image input **202**. Image input **202** may be an image captured using camera **102** on device **100**. In certain embodiments, the captured image is a flood image. In some embodiments, the captured image is a depth map image. The captured image may be captured during an enrollment process, a facial recognition authentication process, a template update process, or another facial recognition process operated by device **100**.

[0041] In certain embodiments, image input **202** is the entire face of the user. FIG. **5** depicts an example of an embodiment of image input **202**. As shown in FIG. **5**, face **300** may take up almost the entire space in image input **202**. Features of face **300** are depicted in image input **202**. Features may include, for example, eyes, nose, mouth, jawline, hairline, and/or outline of the head. In certain embodiments, image input **202** is a 128 pixel image of face **300**. In some embodiments, image input **202** is an image that has been processed after being captured using camera **102**. For example, camera **102** may capture an image showing face **300** as a smaller portion of the image. The captured image may then be processed to produce image input **202** with face **300**, as shown in FIG. **5**. For example, in some implementations, processor **104** may determine the location of a face in the image, determine a bounding box for the face, and crop the image along the borders of the bounding box. The image can also be processed to normalize the illumination levels in the image. In some embodiments, a face detection network (e.g., a face detection neural network) is used to produce image input **202**.

[0042] In process **200**, as shown in FIG. **4**, image input **202** may be provided to network module **204**. Network module **204** may process image input **202** to generate one or more landmark heat maps **206** and occlusion heat map **208**. In certain embodiments, network module **204** is a neural network module. Network module **204** may include network circuitry installed or configured with operating parameters